Infrastructure and Private Sector Investment in Pakistan

by
Robert E. Looney
Naval Postgraduate School
Monterey, California 93943 USA

The purpose of this paper is to assess the role played by infrastructure in Pakistan's economic expansion. Specifically, analysis is focused on the manner in which the expansion in various types of infrastructural facilities interact with private sector investment, and whether there is a long run equilibrium between infrastructure, private investment, and GDP. The main findings suggest that infrastructure's role in this model is not as straightforward as might appear at first. On one level, it appears that in the case of Pakistan the expansion of public infrastructure has played a rather passive role in the country's development. That is public facilities have largely expanded in response to the needs created by private sector investment in manufacturing, rather than strongly initiating private capital formation. However, from another perspective, because infrastructure has responded to tangible needs created by private sector expansion it has, no doubt, been very effective in alleviating real bottlenecks.

Introduction

Pakistan's growth of 5.8 percent per annum over the period from 1973 to 1995 has been very impressive. Still, the country's growth performance has been considered a development puzzle by Ahmed (1994, p. 1) and others, especially in light of a number of disconcerting factors that have prevailed along with rapid growth. These include:

1. Despite the high growth rate, Pakistan's social indicators remain poor—Pakistan is among the countries with the highest adult illiteracy rate and lowest primary school enrollment ratio (IBRD 1995).

2. While the country has been able to avoid high inflation, its fiscal and balance of payments deficits have been large, contributing to a fairly rapid increase in its domestic and external debt burden.
3. Notwithstanding progress in mobilizing domestic saving and raising the rate of investment, the saving and investment efforts remain at a relatively low level as compared with most other developing countries of the world; the domestic saving rate in particular is one of the lowest in the world (IBRD 1995).

Perhaps because of these factors the country's economy has begun to decelerate, averaging a growth of 6.2 percent during the 1980s, but only 5.1 in the 1990-95 period. The outlook for the future is also grim. Faiz (1992, p. 191) for example argues that Pakistan's physical infrastructure is insufficient to support sustained economic development throughout the remainder of the 1990s. Specifically it could stifle the supply response expected from the government's economic reform program, with its special emphasis on privatization, deregulation and export promotion. At the same time, a significant expansion of public expenditures to provide the much needed infrastructure does not appear possible given the government's chronic and growing fiscal deficit financed by unsustainable levels of domestic and foreign borrowing, and its inability to mobilize additional resources. The problem of fiscal deficits may have even reached the point at which they are actually beginning to crowd out a certain amount of private investment (Looney 1995a)

The purpose of this paper is to extend Ahmed's analysis of Pakistan's growth mechanism and Looney's (Looney 1995a) examination of private sector investment by assessing the role played by infrastructure in the country's economic expansion.

Specifically, analysis is focused on the manner in which the expansion in various types of infrastructural facilities interact with private sector investment and whether there is a long run equilibrium between infrastructure, private investment, and GDP. In the shorter run, has public infrastructural development stimulated past surges in private investment or has public infrastructure been passive, largely responding to obvious needs created by expanded private sector capital formation? Based on this analysis several implications are drawn concerning the country’s growth mechanism and future prospects.

Patterns of Investment and Infrastructural Development

As is the case with most countries, the Government of Pakistan does not publish data on the stock of and increments to the country's infrastructure. However, following the procedure of Blejer and Khan (1985), it is possible to approximate increments to the nation's infrastructural base. The basic assumption underlying these proxies is that infrastructure investment is an ongoing process that moves slowly over time and cannot be changed very rapidly.

Operationally, the procedure used here is to make a distinction between types of public investment on the basis of whether it is anticipated or not. Following Blejer and Khan anticipated investment is simply the expected value obtained by regressing each type of public investment on its lagged value. This can be termed the infrastructural component of public investment with the unexpected (actual minus expected value) thought of as the non-infrastructural component.

Pakistan's public sector investment is carried out by a number of jurisdictional bodies. In general, the federal government accounts for about one third of these funds, with the provincial governments providing about half of general government investment and the local governments around 15 percent. These proportions are gradually changing however:

1. While provincial government investment has grown at the fastest rate for the period as a whole, there has been a shift over time with local government investment growing at the slowest rate in the 1970s and at the highest rate in the 1980s.

2. Federal investment has been decelerating over time, growing at around 14 percent in the 1970s, 4.66 percent in the 1980s and at 1.92 percent since 1986.

Linkages between public investment in infrastructure and private sector investment in manufacturing in Pakistan are difficult, if not impossible, to sort out simply by examining the historical record. Still, a number of interesting patterns stand out (Table 1):

1. While private investment in non-manufacturing and small-scale manufacturing activities has been relatively stable over time, investment in large scale manufacturing has shown wide fluctuations since the early 1970s (Table 1): During the 1970s private capital formation in this area averaged just 2.8 percent per annum only to be offset by an expansion of 18.9 percent during the 1980s only to decline to 8.8 percent per annum during the 1990-95 period.

2. While relatively stable over time, private investment in non-manufacturing activities has brown considerably below that of other categories, averaging 4.6

Table 1

Pakistan's Pattern of Growth: Infrastructure, Investment and Output

(Average annual rate of growth)

	Period				
	1973-95	1973-80	1980-90	1985-95	1990-95
Infrastructure					
Total	6.4	12.3	4.0	4.6	3.0
General	7.2	12.4	5.4	4.7	3.7
Energy	10.0	13.2	12.8	10.5	0.6
Transport	7.0	1.4	9.8	8.2	9.5
Local	4.9	1.1	10.2	4.0	0.0
Private Investment					
Large Scale Manufacturing	11.3	2.8	18.9	13.3	8.8
Small Scale Manufacturing	7.5	4.5	8.7	9.9	9.4
Non-Manufacturing	4.6	5.3	4.6	4.8	3.7
Output					
GDP	5.8	5.7	6.2	5.4	5.1
Large Scale Manufacturing	6.4	5.3	7.5	6.2	5.8
Small Scale Manufacturing	8.0	8.6	8.5	8.0	6.3
Non-Manufacturing	5.6	5.6	5.9	5.2	4.9

Notes: All growth figures derived from constant (1985) price series. See text for manner in which infrastructure series derived. Raw data on investment and output was compiled from: IBRD (1993, 1992, 1991, 1983) and Government of Pakistan (1995).

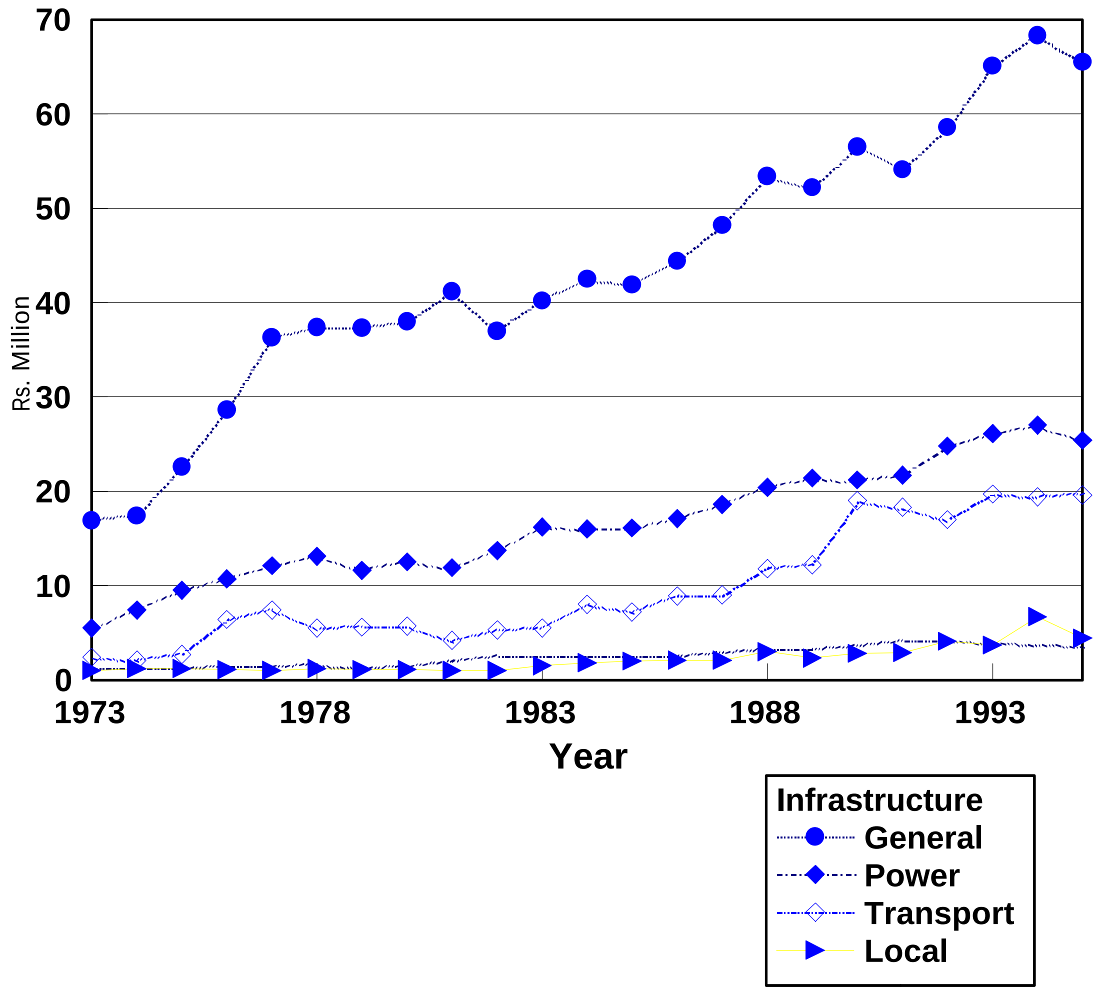
percent for the 1973-95 period compared with 11.3 percent for large scale manufacturing and 7.5 percent for small scale manufacturing.

3. Infrastructure investment has also shown considerable fluctuation over time. However, the dominant pattern here is one of decline, with public allocations to this activity averaging 12.3 percent in the seventies, 4.0 percent in the 1980s and 3.0 percent in the 1990s.

4. Infrastructure itself has also shown great variations of growth (Figure 1) with general infrastructure averaging 7.2 percent for the period (1973-95) as a whole, while that provided by local communities only 4.9 percent.

Figure 1

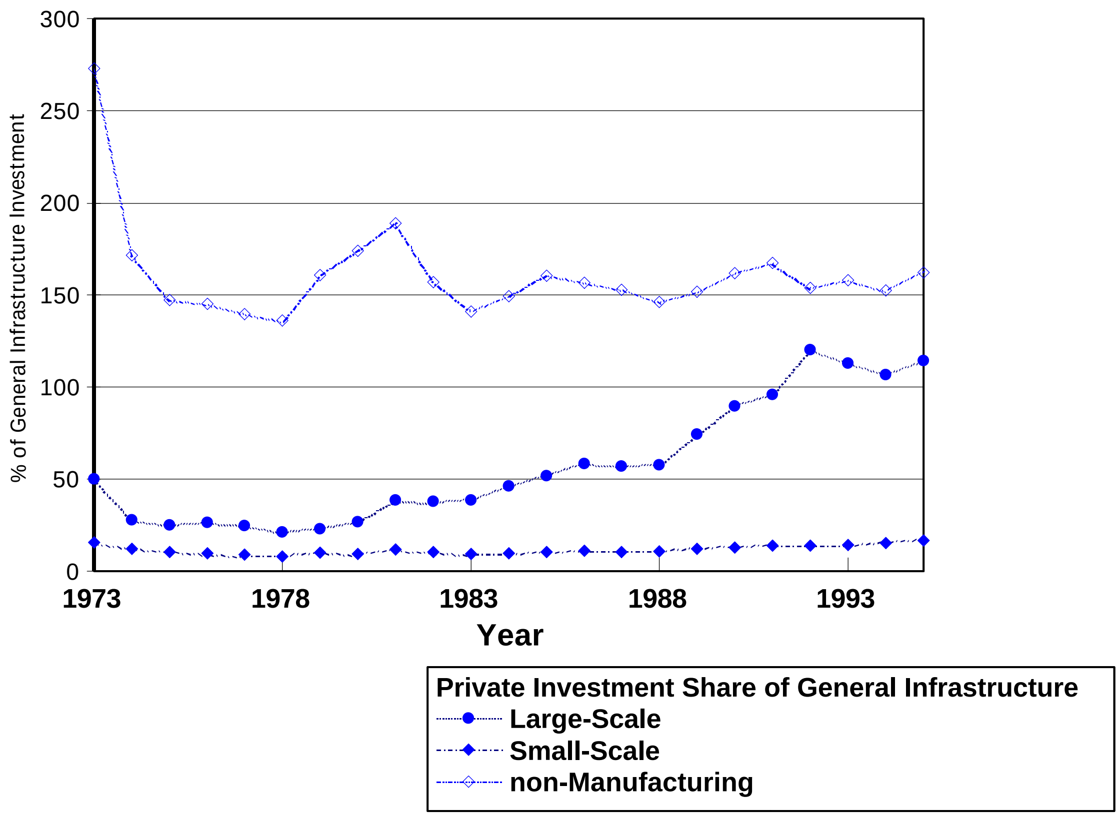
Pakistan: Patterns of Infrastructure Expansion



Over time the growth of infrastructure, private investment and output has produced several interesting patterns. Because of its relatively rapid growth the ratio of private investment in large scale manufacturing to general infrastructure investment has increased fairly dramatically in recent years (Figure 2). This has occurred while private sector investment in small scale manufacturing and that in non-manufacturing activities has evolved into a more stable pattern with that of general infrastructure investment.

Figure 2

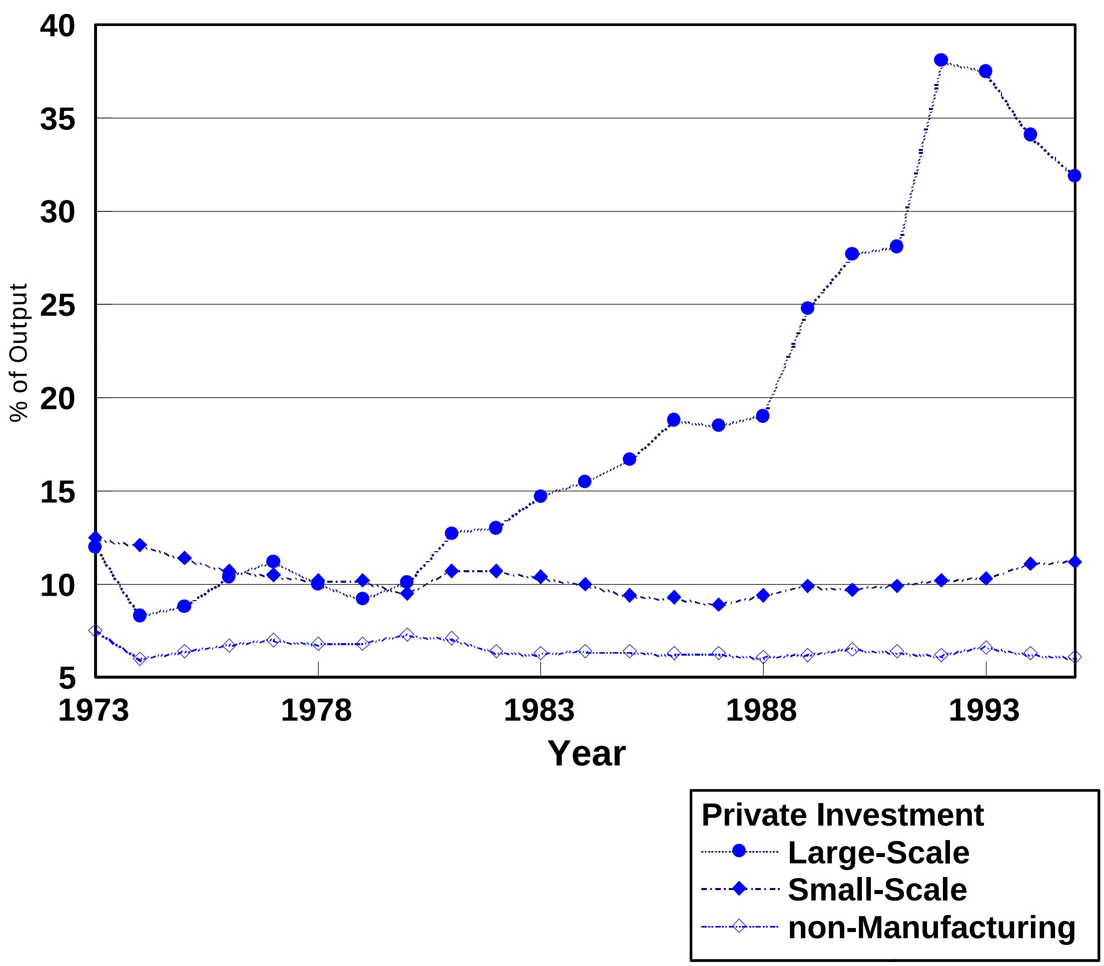
Pakistan: Private Investment and General Infrastructure



An even more dramatic pattern involves that of private investment in large scale manufacturing and large scale manufacturing output (Figure 3). This ratio averaged around 10% in the 1970s, increasing to nearly 20 percent in the 1980s, while in the 1990s reaching the 30% range. However, after peaking at 38 percent in

Figure 3

Pakistan: Private Investment and Output



1992 this ratio declined to around 32 percent by 1995. In contrast, the other types of investment to their respective output show little change over time: private investment in small scale manufacturing has averaged about 10 percent of output of small scale manufacturing while private investment in non-manufacturing about 6.5 percent of non-manufacturing output.

In sum, private investment in large scale manufacturing appears to be more volatile and possess certain growth properties not associated with other forms of private investment. In particular investment of this sort appears to be simultaneously out running its infrastructure support while at the same time becoming less efficient in increasing output. Clearly, a good deal of statistical analysis is needed to determine whether or not or not this is the correct way to characterize private investment in large scale manufacturing, or instead, whether these patterns are simply reflecting some shorter run phenomena. These tests are undertaken in the section that follows.

Long Run Equilibrium Patterns

Over the past few years, important advances have been made in cointegration techniques to estimate long run relationships (Cuthbertson, Hall et al. 1992). The basic idea of cointegration is that two or more variables may be regarded as defining a long-run relationship if they move closely together in the long run, even though they may drift apart in the short run. This long-run relationship is referred to as a cointegrating vector. Because there is a long run relationship between the variables, a regression containing all the variables of a cointegrating vector will have a stationary error term, even if none of the variables taken alone is stationary.

It can be shown (Stock 1987) that in the case of cointegrated non-stationary series, ordinary least squares (OLS) estimates of the cointegrating vector are not only consistent but they converge on their true parameter values much faster than in the stationary case. This proposition does not require the assumption that the regressors be uncorrelated with the error term. In fact the estimates will remain consistent if any of the variables in the cointegrating vector is used as the dependent variable.

More generally, most of the classical assumptions underlying the general linear model are not required in order for OLS or maximum likelihood estimates of the cointegrating vector to have desirable properties. This is particularly important because errors in variables and simultaneity—both of which would normally be cause for concern in the data set used here—will not affect the desirable properties of the estimates. Moreover, because the cointegration approach focuses on long-run relationships, problems associated with variations in infrastructure utilization and with autocorrelation do not arise.

A popular approach to cointegration has been to use unit-root tests such as the Dickey-Fuller (DF) or the augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1981) to determine the degree of integration of the relevant variables and then to apply the Engle and Granger (Engle and Granger 1987) two-step procedure, which is based on an OLS estimate of the cointegrating vector and a unit-root test of its residuals.

Although it is easy to implement, there are a number of problems with the Engle and Granger two-step procedure:

1. First, there may be significant small-sample biases in such OLS estimates of the cointegrating vectors (Banerjee and al. 1986).
2. It has been shown (Hendry and Mizon 1990) that conventional DF and ADF tests generally suffer from parameter instability.
3. Finally, the limiting distributions for the DF and ADF tests are not well defined, implying that the power of these tests is low (Phillips and Ouliaris 1990)
4. Perhaps most damaging is the possibility that any given set of variables may contain more than one long-run relationship: there may be multiple cointegrating vectors. OLS estimates of the cointegrating vector cannot identify multiple long-run relationships or test for the number of cointegrating vectors.

Johansen Cointegration Tests

Johansen's research (Johansen 1988) (Johansen and Juselius 1990) has led to a cointegration estimation methodology that overcomes most of the problems of the two-step approach. This procedure is based on maximum likelihood estimates of all the cointegrating vectors in a given set of variables and provides two likelihood ratio tests for the number of cointegrating factors. Briefly, there are two likelihood ratios to determine the number of cointegrating vectors, r. In the first test, which is based on the maximal eigenvalue, the null hypothesis that there ate at most r cointegrating vectors against the alternative of r + 1 cointegrating vectors.

In the second test which is based on the trace of the stochastic matrix, the null hypothesis is that they are at most r cointegrating vectors against the alternative hypothesis that there are r or more cointegrating vectors. The first test is generally considered to be more powerful because the alternative hypothesis is an equality. These tests can also be used to determine if a single variable is stationary including only that variable in the analysis.

Johansen demonstrates that the likelihood ratio tests have asymptotic distributions that are a function only of the difference between the number of variables and the number of cointegrating vectors. Therefore, in contrast with the DF and ADF tests, the Johansen likelihood ratio tests have well-defined limiting distributions.

Empirical Results

Tests were first performed on the data set to determine the order of integration of the major variables. The first set of tests were obtained using the Johansen procedure which as noted above, has well-defined limiting distributions.

These tests for the orders of integration do not suffer from the parameter instability associated with the DF and ADF tests and are consistent with our use below of the Johansen procedure to estimate the cointegrating vectors. Tests were perform on all variable in their logarithmic form. The null hypothesis that the levels of variables are stationary is rejected for large scale manufacturing and non manufacturing as well as all of the measures of infrastructure (Table 2). For all variables, the null hypothesis that the first differences in logarithmic form are stationary cannot be rejected. Therefore, all series appear to be integrated of order one. The DF and ADF tests produced essentially the same general picture (Table 3)

The tests statistics for infrastructure and private investment from the Johansen procedure are reported in Table 4, where r denotes the number of cointegrating vectors. Briefly, these results report the maximal eigenvalue test of the null hypotheses that there are at most r cointegrating vectors against the alternative of r + 1 cointegrating vectors. Starting with the null hypothesis that there are no cointegrating vectors (r = 0), preliminary tests indicated that private investment in small-scale manufacturing was with any of the various categories of infrastructure, so these results are omitted.

For private investment in large scale manufacturing, the null hypothesis that there are no cointegrating vectors can be rejected for each type of infrastructure suggesting that there is a unique cointegrating vector. However, the eigen values for

Table 2

Johansen Maximum Likelihood Tests of the Order of Integration

Variable	Test Statistic

	Level	First Difference
Private Investment		
Large Scale Manufacturing	0.289	19.297
Small Scale Manufacturing	4.378	7.704
Non-Manufacturing	0.106	26.807
Government Infrastructure		
General Government	3.687	16.452
Energy	3.559	11.432
Transport/Communications	1.097	7.286
Local Government	2.285	11.552
Government Investment		
General Government	4.605	12.742
Energy	3.867	13.416
Transport/Communications	0.058	8.754
Local Government	2.463	10.723
Government Non-Infrastructure		
General Government	9.275	14.795
Energy	12.626	23.049
Transport/Communications	5.627	8.386
Local Government	9.448	13.869

Notes: The null hypothesis is stationarity. The critical values are 3.762 at the 95 percent confidence level and 2.687 at the 90 percent level. The maximum lag in the VAR was set at 2.

All variables except Government non-infrastructure are in logarithmic form.

Computations were performed using Microfit 3.0 (Pesaran and Pesaran 1991).

Table 3

Dickey-Fuller Unit Root Tests for Stationarity

Variable	Level	Difference

	DF	ADF	DF	ADF
Private Investment				
Large Scale Manufacturing	0.606	-0.501	-4.100	-5.208
Small Scale Manufacturing	1.427	2.045	-5.576	-2.824
Non-Manufacturing	0.089	-0.303	-4.149	-6.820
Government Infrastructure				
General Government	-2.547	-1.959	-7.284	-4.658
Energy	-1.281	-1.823	-4.607	-3.621
Transport/Communications	-0.640	0.983	-7.284	-2.734
Local Government	-0.974	-1.439	-3.866	-3.646
Government Investment				
General Government	-3.198	-2.103	-4.534	-3.875
Energy	-1.331	-1.911	-5.042	-4.013
Transport/Communications	-0.628	-0.225	-5.375	-3.051
Local Government	-1.184	-1.500	-4.562	-3.463
Government Non-Infrastructure				
General Government	-3.730	-3.162	-6.232	-4.315
Energy	-5.495	-3.852	-7.771	-6.068
Transport/Communications	-7.357	-2.352	-13.810	-2.976
Local Government	-3.478	-3.198	-5.608	-4.124

Notes: DF = Dickey Fuller Test, ADF = Augmented Dickey Fuller Test. Both reported tests are for the non-trended case. In this instance, the critical value for rejecting at the 95 percent confidence is -3.00 (MacKinnon 1991) .

All variables except Government non-infrastructure are in logarithmic form.

Computations were performed using Microfit 3.0 (Pesaran and Pesaran 1991).

Table 4

Johansen Maximum Likelihood Cointegration Tests:
Private Investment, and Government Infrastructure Expenditures

(Cointegration Likelihood Ratio Test Based on Maximal Eigenvalue of the Stochastic Matrix)

Hypothesis Null	Alternative	Test Statistic	95 percent Critical Value	90 percent Critical Value

General Public Infrastructure				
Large Scale Manufacturing				
r = 0	r = 1	15.991	14.069	12.071
r ≤ 1	r = 2	0.292	3.762	2.687
Non-Manufacturing				
r = 0	r = 1	11.755	14.069	12.071
r ≤ 1	r = 2	3.593	3.762	2.687
Energy Infrastructure				
Large Scale Manufacturing				
r = 0	r = 1	15.885	14.069	12.071
r ≤ 1	r = 2	0.167	3.762	2.687
Non-Manufacturing				
r = 0	r = 1	9.014	14.069	12.071
r ≤ 1	r = 2	3.991	3.762	2.687
Non-Rail Transport and Communications Infrastructure				
Large Scale Manufacturing				
r = 0	r = 1	27.672	14.069	12.071
r ≤ 1	r = 2	0.292	3.762	2.687
Non-Manufacturing				
r = 0	r = 1	11.183	14.069	12.071
r ≤ 1	r = 2	0.048	3.762	2.687
Local Public Infrastructure				
Large Scale Manufacturing				
r = 0	r = 1	18.251	14.069	12.071
r ≤ 1	r = 2	0.594	3.762	2.687
Non-Manufacturing				
r = 0	r = 1	11.265	14.069	12.071
r ≤ 1	r = 2	2.294	3.762	2.687

Notes: Analysis based on maximum of 2 lags in VAR and trended variables. The number of cointegrating vector is denoted by r. Computations were performed using Microfit 3.0 (Pesaran and Pesaran 1991).

private investment in non manufacturing are below the critical level for rejecting the null hypothesis suggesting that there is no long run equilibrium relationship between this type of investment and the government's addition to the stock of the various types of infrastructure. Similar results were obtained from the likelihood ratio test based on the trace of the stochastic matrix.

Further analysis also suggested that private investment in large scale manufacturing was not only cointegrated with the various types of infrastructure, but with Gross Domestic Product as well (Table 5). Specifically the three variables form one cointegrating vector in the case of energy infrastructure, transport and communications and general infrastructure. For local infrastructure the three variables form two cointegrating vectors in the non-trended case, but not in the trended one.

Summing up, private investment in large scale manufacturing appears to have a long run equilibrium pattern with the various measures of infrastructure as well as the overall level of economic activity. Investment in both small-scale manufacturing and in non-manufacturing activities does not appear to from these close ties in the longer run with either infrastructure or output. These findings of course do not preclude short run linkages between private investment in small-scale manufacturing/non manufacturing and infrastructure or GDP. The next section checks for the existence of this type of linkage as well as the directional linkage between investment in large scale manufacturing and infrastructure/GDP.

Patterns of Causation

As noted, a major issue in the analysis of the role of infrastructure in Pakistan's post 1971 development centers around the direction of causation: does infrastructure affect private sector investment through cost reduction linkages, or does it simply

Table 5

Test of Long-Run Balance with Private Investment in Large Scale Manufacturing

Hypothesis Null	Alternative	λ-max Statistic	95 percent Critical Value	Trace Statistic	95 percent Critical Value
GDP, and Energy Infrastructure					
Non Trended Case					
r = 0	r = 1	27.49	22.00	44.79	32.00
r ≤ 1	r = 2	11.83	15.67	17.29	19.96
r ≤ 2	r = 3	5.46	9.24	5.46	9.24
Trended Case					
r = 0	r = 1	18.61	20.96	29.31	29.68
r ≤ 1	r = 2	10.66	14.07	10.70	15.41
r ≤ 2	r = 3	0.04	3.76	0.04	3.76
GDP and Transport/Communication Infrastructure					
Non Trended Case					
r = 0	r = 1	32.45	22.00	56.72	34.91
r ≤ 1	r = 2	14.78	15.67	24.27	19.96
r ≤ 2	r = 3	9.48	9.24	9.48	9.24
Trended Case					
r = 0	r = 1	31.76	20.96	43.73	29.68
r ≤ 1	r = 2	11.67	14.07	11.97	15.41
r ≤ 2	r = 3	0.30	3.76	0.30	3.76
GDP and Local Infrastructure					
Non Trended Case					
r = 0	r = 1	23.45	22.00	49.10	34.91
r ≤ 1	r = 2	16.44	15.67	25.65	19.96
r ≤ 2	r = 3	9.21	9.24	9.21	9.24
Trended Case					
r = 0	r = 1	21.14	20.96	31.69	29.68
r ≤ 1	r = 2	10.13	14.07	10.55	15.41
r ≤ 2	r = 3	0.42	3.76	0.42	3.76
GDP and General Infrastructure					
Non Trended Case					
r = 0	r = 1	27.65	22.00	46.67	34.91
r ≤ 1	r = 2	12.11	15.67	19.03	19.96
r ≤ 2	r = 3	6.91	9.24	6.91	9.24
Trended Case					
r = 0	r = 1	18.32	20.96	29.24	29.68
r ≤ 1	r = 2	10.57	14.07	10.91	15.41
r ≤ 2	r = 3	0.34	3.76	0.34	3.76

Notes: Analysis based on maximum of 2 lags in VAR. The number of cointegrating vector is denoted by r. Computations were performed using Microfit 3.0 (Pesaran and Pesaran 1991).

respond to the needs created by an expanded private sector capital stock? An earlier study (Looney 1995a) suggested the dominant links might be from private investment to infrastructure. However since the main focus of that study was on the government's fiscal operations, infrastructure was given only minor attention with no analysis of the various types of infrastructure (energy, transport and the like) undertaken. In addition, that study did not examine these linkages in the context of cointegration or VAR simulation.

Several strategies are available for assessing the issue of causality. The original and most widely used of these tests was developed by Granger (1969, 1980,1988). According to this test, infrastructure causes (say) growth of private sector investment in manufacturing (PIM), if this series can be predicted more accurately by past values of infrastructure investment than by past growth patterns. To be certain that causality runs from infrastructure to PIM, past values of infrastructure must also be more accurate than past values of private investment at predicting allocations to infrastructure.

Granger Test

More formally, Granger (1969) defines causality such that X Granger causes (G-C) Y if Y can be predicted more accurately in the sense of mean square error, with the use of past values of X than without using past X. Based upon the definition of Granger causality, a simply bivariate autoregressive (AR) model for infrastructure (INF) and PIM can be specified as follows:

$$(1)\ PIM(t) = c + \sum_{i=1}^{p} a(i)PIM(t-i) + \sum_{j=1}^{q} b(j)INF(t-j) + u(t)$$

$$(2)\ INF(t) = c + \sum_{i=1}^{r} d(i)\ INF(t-1) + \sum_{j=1}^{s} e(j)PIM(t-j) + v(t)$$

where PIM is the growth in private sector investment in manufacturing and INF = the growth in infrastructural expenditures; p, q, r and s are lag lengths for each variable in the equation; and u and v are serially uncorrelated white noise residuals. By assuming that error terms (u, v) are "nice" ordinary least squares (OLS) becomes the appropriate estimation method.

Within the framework of unrestricted and restricted models, a joint F-test is appropriate for causal detection. Where:

$$(3)\ F = \frac{(RSS(x) - RSS(u)/(df(x) - df(u)}{RSS(u)/df(u)}$$

where RSS(r) and RSS(u) are the residual sum of squares of restricted and unrestricted models, respectively; and df(r) and df(u) are, respectively, the degrees of freedom in restricted and unrestricted models.

The Granger test detects causal directions in the following manner: first, unidirectional causality from INF to PIM if the F-test rejects the null hypothesis that past values of INF in equation (1) are insignificantly different from zero and if the F-test cannot reject the null hypothesis that past values of PIM in equation (2) are insignificantly different from zero. That is, PIM causes INF but PIM does not cause INF. Unidirectional causality runs from PIM to INF if the reverse is true. Second, bi-directional causality runs between INF and PIM if both F-test statistics reject the null hypotheses in equations (1) and (2). Finally, no causality exists between INF and PIM if we can not reject both null hypotheses at the conventional significance level.

The results of Granger causality tests depend critically on the choice of lag length. If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag is greater than the true lag length, the inclusion of irrelevant lags causes estimates to be inefficient. While it is possible to choose lag lengths based on preliminary partial autocorrelation methods, there is no **a priori** reason to assume lag lengths equal for all types of infrastructure.

The Hsaio Procedure

To overcome the difficulties noted above, Hsaio (Hsiao 1981) developed a systematic method for assigning lags. This method combines Granger Causality and Akaike's final prediction error (FPE), the (asymptotic) mean square prediction error, to determine the optimum lag for each variable. In a paper examining the problems encountered in choosing lag lengths, Thornton and Batten (1985) found Hsiao's method to be superior to both arbitrary lag length selection and several other systematic procedures for determining lag length.

The first step in Hsiao's procedure is to perform a series of autoregressive regressions on the dependent variable. In the first regression, the dependent variable has a lag of one. This increases by one in each succeeding regression. Here, we estimate M regressions of the form:

$$(4) \qquad G(t) = a + \sum_{i=1}^{m} b(t-1)G(t-1) + e(i)$$

where the values of m range from 1 to M. For each regression, we compute the FPE in the following manner:

$$(5) \quad FPE(m) = \frac{T + m + 1}{T - m - 1} \quad ESS(m)/T$$

Where: T is the sample size, and FPE(m) and ESS(m) are the final prediction error and the sum of squared errors, respectively. The optimal lag length, m*, is the lag length which produces the lowest FPE. Having determined m* additional regressions expand the equation with the lags on the other variable added sequentially in the same manner used to determine m*. Thus we estimate four regressions of the form:

$$(6)\ G(t) = a + \sum_{i=1}^{m^*} b(t-1)G(t-1) + \sum_{I=1}^{n} c(t-1)D(t-1) + e(i)$$

with n ranging from one to four. Computing the final prediction error for each regression as:

$$FPE(m^*,n) = \frac{T + m^* + n + 1}{T - m^* - n - 1} ESS(m^*,n)/T$$

we choose the optimal lag length for D, n* as the lag length which produces the lowest FPE. Using the final prediction error to determine lag length is equivalent to using a series of F tests with variable levels of significance.

The first term measures the estimation error and the second term measures the modeling error. The FPE criterion has a certain optimality property that "balances the risk due to bias when a lower order is selected and the risk due to increases in the variance when a higher order is selected (Hsiao 1979)." As noted by Judge (Judge, Griffiths et al. 1982) et.al., an intuitive reason for using the FPE criterion is that longer lags increase the first term but decrease the RSS of the second term, and thus the two opposing forces optimally balanced when their product reaches its minimum.

Depending on the value of the final prediction errors, four cases are possible: (a) **Infrastructure causes Private Investment** when the prediction error for private investment decreases when infrastructure investment is included in the growth equation. In addition, when private investment is added to the infrastructure equation, the final prediction error should increase; (b) **Private Investment causes Infrastructure** when the prediction error for private investment increases when infrastructure is added to the regression equation for private investment, and is reduced when private investment is added to the regression equation for infrastructure; (c) **Feedback** occurs when the final prediction error decreases when infrastructure is added to the private investment equation, and the final prediction error decreases when private investment is added to the infrastructure equation; and (d) **No Relationship** exists when the final prediction error increases both when infrastructure is added to the private investment equation and when private investment is added to the infrastructure equation.

Operational Procedures

The tests for the order of integration (Tables 2 and 3) found that the first differences of the logarithmic values for all private investment and infrastructure variables are stationary and hence valid forms for the causality analysis. In addition to infrastructure, total (actual) government investment and non-infrastructure allocations were also introduced into the analysis. As noted total or actual government investment is the annual figures from which our measure of infrastructure was derived. Non-infrastructural investment is simply the difference between actual investment and its infrastructural component.

There is no theoretical reason to believe that infrastructure and private investment in manufacturing have a set lag relationship--that is they impact on one another over a fixed time period. The period could be rather short run involving largely the spin-off from construction or longer term as either term expands from the stimulus provided by the other. To find the optimal adjustment period of impact, lag structures of up to six years were estimated. The lag structure with the highest level of statistical significance was the one chosen best depict the relationship under consideration (the optimal lag reported in Table 5).

Results

The analysis produced a number of interesting results:

1. For general government expenditures (Table 6) the dominant pattern appears to be one from investment in large scale manufacturing to infrastructure. The linkage is positive with increased private investment stimulating a follow on increase in general infrastructure.
2. This same general pattern caries over to non-infrastructure and total investment. However in these cases the optimal lag is only one year as opposed to two years for the link between private investment and general infrastructure.
3. While private investment in non-manufacturing activities also affects general infrastructure, the link is negative. That is, an expansion of this type of infrastructure tends to lower the future provision of general government infrastructure. This phenomena, however, does not appear to apply to total public investment nor to its non-infrastructural component.

Table 6

Pakistan: Interaction of Private Investment and General Public Capital Expenditures

(log differences)

	Causation Patterns				Dominant Pattern
	A	B	C	D	
Infrastructure					
Private Investment--Large Scale Manufacturing					
1	2	1	2		Private→
	(0.16e-1)	(0.17e-1)	(0.66e-2)	(0.61e-2)	Public (+)
Private Investment—Small Scale Manufacturing					
	1	2	1	1	No
	(0.29e-2	(0.30e-2)	(0.66e-2)	(0.68e-2)	Relationship
Private Investment--Non-Manufacturing					
	1	1	1	1	Private→
	(0.21e-2)	(0.23e-2)	(0.66e-2)	(0.63e-2)	Public (-)
Non-Infrastructure					
Private Investment—Large-Scale Manufacturing					
	1	3	1	2	Private→
	(0.18e-1)	(0.19e-1)	(2.16)	(1.74)	Public (+)
Private Investment—Small Scale Manufacturing					
	1	1	1	1	No
	(0.30e-2)	(0.32e-2)	(2.16)	(2.32)	Relationship
Private Investment—Non-Manufacturing					
	1	1	1	4	No
	(0.21e-2)	(0.23e-2)	(2.16)	(2.18)	Relationship
Total Investment					
Private Investment—Large-Scale Manufacturing					
	1	3	4	2	Private→
	(0.17e-1)	(0.18e-1)	(0.56e-2)	(0.49e-2)	Public (+)
Private Investment—Small-Scale Manufacturing					
	1	3	4	1	No
	(0.29e-2)	(0.31e-2)	(0.56e-2)	(0.59e-2)	Relationship
Private Investment—Non-Manufacturing					
	1	1	4	2	No
	(0.21e-2)	(0.23e-2)	(0.56e-2)	(0.61e-2)	Relationship

Notes: See Table 10.

4. Private investment in small scale manufacturing did not form any significant causal patterns with public investment or infrastructure.

   For energy infrastructure (Table 7);

1. The positive link from private investment in large scale manufacturing to energy infrastructure is again present as well as a similar link from private investment in small scale manufacturing.
2. In contrast private investment in non-manufacturing activities forms a complex feedback pattern with energy infrastructure, with expanded private investment again reducing infrastructure, but expanded infrastructure providing a stimulus to further investment by the private sector.

Again in the case of non-rail transport and communications (Table 8), private investment in both large and scale manufacturing simulated a future expansion of public sector infrastructure. This was also the case with regard to non-infrastructure and total investment. Again however, expanded private investment in non-manufacturing activity subsequently reduced the government's allocation to infrastructure.

Finally the same basic pattern appears to occur with regard to local infrastructure and investment (Table 9). Again the dominant pattern is one whereby expanded private sector investment in large scale manufacturing tends to induce an response from the public sector in the form of an expanded allocation to infrastructure activities.

The final causality tests examine the linkage between private investment and GNP as well as the output specific to each type of investment (for example, private investment in large scale manufacturing and GDP in large scale manufacturing). As

Table 7

Pakistan: Interaction of Private Investment and Public Power Capital Expenditures

(log differences)

	Causation Patterns				Dominant Pattern
	A	B	C	D	
Infrastructure					
Private Investment--Large Scale Manufacturing					
1	3	1	4	1	Private→
	(0.17e-1)	(0.19e-1)	(0.42e-1)	(0.40e-2)	Public (+)
Private Investment—Small Scale Manufacturing					
	1	1	1	1	Private→
	(0.30E-2)	(0.33e-2)	(0.42e-1)	(0.39e-1)	Public (+)
Private Investment—Non Manufacturing					
	1	4	1	3	Feedback
	(0.21e-2)	(0.16e-2)	(0.42e-1)	(0.39e-1)	Priv→Pub (-) Pub→Priv (+)
Non-Infrastructure					
Private Investment—Large Scale Manufacturing					
	1	1	1	1	No
	(0.18e-1)	(0.20e-1)	(4.70)	(5.25)	Relationship
Private Investment—Small-Scale Manufacturing					
	1	1	1	1	No
	0.30e-2)	(0.33e-2)	(4.70)	(4.88)	Relationship
Private Investment—Non-Manufacturing					
	1	1	1	1	
	(0.21e-2)	(0.23e-2)	(4.70)	(4.59)	
Total Investment					
Private Investment--Large-Scale Manufacturing					
	1	1	1	1	No
	(0.18e-1)	(0.20e-1)	(0.43e-1)	(0.46e-1)	Relationship
Private Investment—Small-Scale Manufacturing					
	1	1	1	1	No
	(0.30e-2)	(0.32e-2)	(0.43e-1)	(0.47e-1)	Relationship
Private Investment—Non-Manufacturing					
	1	2	1	1	Private→
	(0.21e-2)	(0.22e-2)	(0.43e-1)	(0.42e-1)	Public (-)

Notes: See Table 10.

Table 8

Pakistan: Interaction of Private Investment and Public Non-Rail Transport and Communication Capital Expenditures

(log differences)

	Causation Patterns A	B	C	D	Dominant Pattern
Infrastructure					
Private Investment-Large Scale Manufacturing	1 (0.18e-1)	1 (0.19e-1)	1 (0.46e-1)	4 (0.17e-1)	Private→ Public (+)
Private Investment-Small Scale Manufacturing	1 (0.30e-2)	1 (0.33e-2)	1 (0.46e-2)	3 (0.29e-2)	Private→ Public (+)
Private Investment in Non-Manufacturing	1 (0.21e-2)	1 (0.23e-2)	1 (0.46e-1)	2 (0.38e-1)	Private→ Public (-)
Non-Infrastructure					
Private Investment—Large-Scale Manufacturing	1 (0.18e-1)	1 (0.20e-1)	1 (1.17)	1 (0.80)	Private→ Public (+)
Private Investment—Small-Scale Manufacturing	1 (0.30e-2)	1 (0.32e-2)	1 (1.17)	2 (0.94)	Private→ Public (+)
Private Investment—Non-Manufacturing	1 (0.21e-2)	1 (0.23e-2)	1 (1.17)	1 (1.28)	No Relationship
Total Investment					
Private Investment—Large Scale Manufacturing	1 (0.18e-1)	1 (0.20e-1)	1 (0.94e-1)	2 (0.33e-1)	Private→ Public (+)
Private Investment—Small Scale Manufacturing	1 (0.30e-2)	1 (0.32e-2)	1 (0.94e-1)	2 (0.88e-1)	Private→ Public (+)
Private Investment—Non-Manufacturing	1 (0.21e-2)	1 (0.23e-2)	1 ().94e-1)	1 (0.91e-1)	

Notes: See Table 10.

Table 9

Pakistan: Interaction of Private Investment and Local Public Capital Expenditures

(log differences)

	Causation Patterns				Dominant Pattern
	A	B	C	D	
Infrastructure					
Private Investment in Large-Scale Manufacturing	1 (0.18e-1)	1 (0.20e-1)	3 (0.20e-1)	4 (0.14e-1)	Private→ Public (+)
Private Investment in Small-Scale Manufacturing	1 (0.29e-2)	2 (0.30e-2)	3 (0.20e-1)	4 (0.21e-1)	No Relationship
Private Investment in Non-Manufacturing	1 (0.21e-2)	1 (0.17e-2)	3 (0.20e-1)	1 (0.16e-1)	Feedback Priv→Pub (+) Pub→Priv (-)
Non-Infrastructure					
Private Investment in Large-Scale Manufacturing	1 (0.17e-1)	1 (0.18e-1)	1 (0.114)	4 (0.901)	Private→ Public (-)
Private Investment in Small-Scale Manufacturing	1 (0.30e-2)	1 (0.31e-2)	1 (0.114)	3 (0.101)	Private→ Public (-)
Private Investment in Non-Manufacturing	1 (0.21e-2)	1 (0.22e-2)	1 (0.114)	1 (0l.120)	No Relationship
Total Investment					
Private Investment in Large-Scale Manufacturing	1 (0.18e-1)	1 (0.17e-1)	3 (0.28e-1)	4 (0.23e-1)	Private→ Public (-)
Private Investment in Small-Scale Manufacturing	1 (0.30e-1)	3 (0.32e-1)	3 (0.27e-1)	3 (0.28e-1)	No Relationship
Private Investment in Non-Manufacturing	1 (0.21e-2)	2 (0.18e-2)	3 (0.28e-1)	4 (0.27e-1)	Feedback Priv→Pub (+) Pub→Priv (-)

Notes: See Table 10.

noted earlier, private investment in large scale manufacturing is cointegrated with GDP and infrastructure. Based on the causality tests (Table 10) the linkage of this relationship is one from GDP to investment. That is the private sector responds positively to increased GDP and large scale manufacturing output measure of output.

Summing up, the results from the causality analysis are consistent with the patterns of cointegration. It appears that private investment in large scale manufacturing is closely linked with all types of infrastructure as well as with GDP. However, the same can not be said for the other types of private investment. In particular private investment in non-manufacturing has several short run negative linkages with infrastructure, while private investment in small scale manufacturing only has several weak, albeit weak short term links with infrastructure. Only private investment in large scale manufacturing has links with GDP and its respective type of output.

Vector Autoregression Analysis

These causal patterns, especially that of private investment in large scale manufacturing are further illustrated through the use of a vector autoregression (VAR). A vector autoregression is a system in which every equation has the same right hand variables, and those variables include lagged values of all of the endogenous variables. While the coefficients themselves of the systems are difficult to interpret, the impulse response functions and variance decompositions of the system provide useful information on the manner in which the system variables interact with each other over time.

The mathematical form of a VAR is

Table 10

Pakistan: Interaction of Private Investment and Gross Domestic Product

(log differences)

	Causation Patterns				Dominant Pattern
	A	**B**	**C**	**D**	
GDP					
Private Investment in Large Scale Manufacturing and GDP					
	1	3	1	1	GDP→
	(0.18e-1)	(0.14e-1)	(0.41e-3)	(0.43e-1)	Private (+)
Private Investment in Large Scale Manufacturing and Large Scale Manufacturing Output					
	1	2	1	1	Output→
	(-.18e-1)	0.12e-1)	0.90e-3	0.94e-3)	Private (+)
Private Investment in Small Scale Manufacturing and GDP					
	1	1	1	1	No
	(0.29e-2)	(0.30e-2)	(0.41e-3)	(0.43e-3)	Relationship
Private Investment in Small Scale Manufacturing and Small Scale Manufacturing Output					
	1	2	1	1	No
	(0.30e-2)	(0.32e-2)	(0.15e-2)	(0.16e-2)	Relationship
Private Investment in Non-Manufacturing					
	1	1	1	1	No
	(0.21e-2)	(0.23e-2)	(0.41e-3)	(0.46e-3)	Relationship
Private Investment in Non-manufacturing and non-manufacturing output					
	1	1	1	1	No
	(0.21e-2)	(0.23e-2)	(0.50e-3)	(0.56e-3)	Relationship

Notes: Summary of results obtained from Granger Causality Tests. A Hsaio Procedure was incorporated General Public Investment to determine the optimal lag. All variables except non- infrastructural investment in their log difference form. Non-infrastructural investment is in it non differenced level. Infrastructure is the valued predicted by regressing public investment on its value in the previous year. Non-Infrastructure is actual investment minus infrastructure. Regression Patterns: A = private investment on private investment; B = public investment (infrastructure) on private investment; C = investment (infrastructure) on investment (infrastructure); and D = private investment on public investment (infrastructure). The Dominant pattern is that with the lowest final prediction error. The signs (+,-) represent the direction of impact. In the case of feedback the two signs represent the lowest final prediction error of relationships **B and D**. Each of the variables was regressed with 1, 2, 3, and 4 year lags. ( ) = final prediction error.

$$y_t = A_t y_{t-1} + \ldots A_n y_{t-N} + Bx_t + \varepsilon_t$$

where y_t is a vector of endogenous variables, x_t is a vector of exogenous variables, $A_1 \ldots A_N$ and B are matrices of coefficients to be estimated and ε_t is a vector of innovations that are correlated with each other but uncorrelated with their own lagged values and uncorrelated with y_{t-1} through y_{t-N} and x_t.

An impulse response function traces the response of an endogenous variable to a change in one of the innovations. Specifically, it traces the effect on current and future values of the endogenous variable of a one standard deviation shock to one of the innovations.

The ambiguity in interpreting impulse response functions arises from the fact that the errors are never totally uncorrelated. When the errors are correlated they have a common component which cannot be identified with any specific variable. A somewhat arbitrary method of dealing with this problem is to attribute all of the effect of any common component to the variable that comes first in the VAR. More technically, the errors are orthoganalized by a Cholesky decomposition so that the covariance matrix of the resulting innovations is diagonal. While the Cholesky decomposition is widely used, it is a rather arbitrary method of attributing common effects. Unfortunately, changing the order or equations can often dramatically change the impulse responses (Hamilton 1994, pp. 318-23).

To eliminate this problem to the extent possible the following analysis orders the variables based on the causality tests. Specifically, since GDP causes investment in large scale manufacturing which in turn causes infrastructure investment, the three variables were introduced in this order in the VAR.

While the total set of impulse response functions is to extensive to present here[1], several of the variance decompositions of the VAR provide useful information about the relative importance of the random innovations. For the case of GDP, private investment in large scale manufacturing and general infrastructure (Table 11), a separate variance decomposition is calculated for each endogenous variable. The first column is the forecast error of the variable each year in the ten year time horizon. The source of this forecast error is variation in the current and future values of the innovations. The remaining columns give the percentage of the variance due to specific innovations. One period ahead, all of the variation in a variable comes from its own innovation, so that the first number is always 100 percent.

Because the variable are cointegrated, the VAR specification was a vector error correction. The variance decomposition simulations confirm our conclusions about the manner in which GDP, private investment in large scale manufacturing and infrastructure interact. Specifically:

1. After ten periods, 80 percent of the variance in GDP can still be explained by its own innovation, with only 18 percent accounted for the innovation in private investment and only 1.5 percent from general infrastructure.
2. In contrast after ten periods nearly 40 percent of the variance in private investment in large scale manufacturing can be explained by innovations in GDP while infrastructure can account for just slightly less than 5%.
3. Finally after 10 periods innovations in both GDP and private investment in large scale manufacturing each account for over 40 percent of the variance in infrastructure.

   The other three types of infrastructure produced similar results.

Table 11

Variance Decomposition Tests:
GDP, Private Investment in Large Scale Manufacturing and General Infrastructure

Period	Standard Error	GDP	Private Invest. Large-Scale Manuf.	General Infrastructure
Variance Decomposition of GDP				
1	0.015415	100.0000	0.000000	0.000000
2	0.020331	88.83384	8.256105	2.910051
3	0.023229	86.29968	10.11658	3.583736
4	0.025594	84.07996	12.96403	2.956009
5	0.028302	80.94714	16.61246	2.440396
6	0.030993	80.65518	17.30747	2.037347
7	0.033550	81.18822	16.96336	1.848415
8	0.035802	81.31945	16.88398	1.796572
9	0.037749	80.95996	17.34965	1.690390
10	0.039582	80.42177	18.02891	1.549318
Variance Decomposition of Private Investment in Large Scale Manufacturing				
1	0.092517	22.35897	77.64103	0.000000
2	0.146377	36.37501	61.20123	2.423762
3	0.170531	36.91607	56.95841	6.125515
4	0.181574	35.70273	58.03561	6.261659
5	0.188694	35.69508	58.50005	5.804871
6	0.198337	37.20479	57.53761	5.257597
* 7	0.212943	39.10993	56.11951	4.770562
8	0.228387	39.97636	55.23728	4.786364
9	0.240208	40.07945	55.07146	4.849098
10	0.248767	40.12698	55.17081	4.702217
Variance Decomposition of General Infrastructure				
1	0.040074	26.27943	3.989164	69.73141
2	0.047181	46.38718	3.076375	50.53644
3	0.071434	48.27172	26.67517	25.05310
4	0.084434	44.05728	34.13296	21.80976
5	0.088317	42.08429	36.73112	21.18459
6	0.090041	41.19296	38.39085	20.41620
7	0.092806	41.20381	39.42588	19.37031
8	0.098177	42.08192	40.54348	17.37459
9	0.104693	42.10843	41.95493	15.93664
10	0.109651	41.40822	43.41926	15.17252

Note: Estimates are based on a vector autoregression model. Because the variables are cointegrated, the VAR specification is a vector error correction. The model uses a maximum of two lags and assumes a linear trend in the data and one cointegrating equation. Based on causality tests, VAR ordering is GDP, Private Investment, Infrastructure. Computations made using EViews 2.0 (Hall 1995).

Finally, to confirm that our conclusions about the direction of causality are from large scale manufacturing to infrastructure, both variables were introduced into VAR with the initial order of private investment followed by infrastructure. Then the VAR was estimated using the order of infrastructure followed by private investment. The results of this exercise (Table 12) confirm that the relative importance of private investment in affecting infrastructure. Specifically in the first set with private investment coming first in the VAR, only 5 percent of its variance can be explained by infrastructure after 5 periods. On the other hand when infrastructure comes first in the VAR, private investment in large scale manufacturing explains 65 percent of its variance after 5 periods. Again, similar results were obtained for the other three types of infrastructure.

While the links between private investment in large scale manufacturing and infrastructure appear pervasive across a wide variety of public facilities, it should be noted that other factors have been important in affecting the pattern and timing of this relationship. For example the regional relocation of private investment due to ethnic disturbances, particularly in the post 1985 period has also been an important factor in stimulating both the expansion of infrastructure and private investment in the Punjab region and away from the Sind[2]. While beyond the scope of this paper, it would be of interest for future research to examine phenomenon such at that of regional relocation of industry to determine the extent to which they may alter the patterns noted above.

Conclusions

Recent cointegrating and causality techniques that focus on the identification of long-run relationships are particularly appropriate to the study of long run growth.

Table 12

Variance Decomposition Tests:

Private Investment in Large Scale Manufacturing and General Public Infrastructure

Period	Standard Error	Private Invest. Large-Scale Manuf	General Infrastructure
VAR Ordering: Investment Infrastructure			
Variance Decomposition of Private Investment in Large Scale Manufacturing			
1	0.098609	100.0000	0.000000
2	0.148375	98.51113	1.488875
3	0.170866	94.56662	5.433376
4	0.181170	94.72639	5.273613
5	0.188077	95.00771	4.992295
Variance Decomposition of General Infrastructure			
1	0.043147	16.35713	83.64287
2	0.046941	27.27796	72.72204
3	0.066166	61.11204	38.88796
4	0.076593	69.08465	30.91535
5	0.078683	69.29911	30.70089

Period	Standard Error	General Infrastructure	Private Investment Large Scale Manufacturing
VAR Ordering: Infrastructure Investment			
Variance Decomposition of General Infrastructure			
1	0.043147	100.0000	0.000000
2	0.046941	92.29714	7.702862
3	0.066166	48.41710	51.58290
4	0.076593	36.62300	63.37700
5	0.078683	34.78848	65.21152
Variance Decomposition of Private Investment in Large Scale Manufacturing			
1	0.098609	16.35713	83.64287
2	0.148375	10.70474	89.29526
3	0.170866	8.078039	91.92196
4	0.181170	7.689820	92.31018
5	0.188077	9.001818	90.99818

Note: Estimates are based on a vector autoregression model. Because the variables are cointegrated, the VAR specification is a vector error correction. The model uses a maximum of two lags and assumes a linear trend in the data and one cointegrating equation. Based on causality tests, VAR ordering is GDP, Private Investment, Infrastructure. Computations made using EViews 2.0 (Hall 1995).

The application of these techniques to Pakistani data has yielded a number of interesting results, the most important of which is that Pakistan’s longer run growth pattern since 1973 can be characterized by the balance achieved between GDP, infrastructure investment, and private investment in large scale manufacturing. These variables are in equilibrium in the long run and clearly complement each other with expanded GDP growth simulating private investment in manufacturing which in turn creates effective demand for additional infrastructure facilities. Given the government’s emphasis on industrial expansion, the provision of infrastructure to large scale industry appears to be a key element in this strategy. In turn other studies (Ahmed 1994) (Looney 1995) have shown that GDP’s growth can be explained by a conventional growth model stressing direct factor inputs.

Infrastructure’s role in this model is not as straightforward as might appear at first. On one level, it appears that in the case of Pakistan the expansion of public infrastructure has played a rather passive role in the country's development. That is public facilities have largely expanded in response to the needs created by private sector investment in manufacturing, rather than strongly initiating private capital formation. However, from another perspective, because infrastructure has responded to tangible needs created by private sector expansion it has, no doubt, been very effective in alleviating real bottlenecks. This phenomenon would be consistent with the commonly held view that the country suffers from a lack of infrastructure in many key areas. In any case, the overall effect of this pattern of linkages implies that the rate of return on infrastructure investment is very high in Pakistan and, as such, the country has been able to sustain rapid rates of growth, despite rather levels of investment.

While conjectural, the negative link between private investment in non-manufacturing and several forms of infrastructure may reflect competition for real resources. In a resource poor country such as Pakistan, it is easy to envisage situations where private investors are able to bid resources (labor, materials, equipment) away from public authorities, resulting in delays or postponements in public projects. Apparently the government is, however, inclined to proceed with projects that affect large scale industry but less willing if the projects clearly affect the non-manufacturing sector of the economy.

The net result is to maintain the long run balance involving private investment in large scale manufacturing-GDP-infrastructure at perhaps the expense of other areas of the economy (Looney 1994). While this model may have served the country well in the past, it is not clear that it is one that is sustainable. The rising private investment to infrastructure and output ratios noted in Figures 2 and 3 are perhaps indicative of the strains that may undermine this relationship. In particular, the productivity of private investment appears to be falling, perhaps due to the inability of infrastructure to keep pace with the rapidly growing needs placed upon it an expanding private sector.

These results have a number of policy implications. It said (Haque 1996) that Pakistan's time-tested growth hovers around a potential of 6%. An agricultural failure leads to a plunge into the 2-3 % range, and an industrial recession depresses it to 4-5 % range. An occasional jump to 7% has almost always been the result of revival from a low base. No doubt a low rate of investment of under 20 %, together with lagging infrastructure is a major reason for the economy to get set in the 6 % mold. Experts estimate (Shiekh 1996) that if the Ninth Plan (1998-2003) is to achieve a GDP growth rate of seven per cent per annum, an investment of over one trillion rupees will be required.

Much of the public sector's past investment took place with low interest rates. As the country becomes more integrated in the world economy and interest rates increase, this together with high levels of debt will greatly limit the government's ability to accommodate large scale manufacturing's infrastructure needs. If this occurs, the country is likely to enter a prolonged period of economic decline.

The causality results reported above imply that infrastructure investment appears to respond to specific industrial needs, especially those created by investment in large scale manufacturing. Perhaps one way of assuring adequate investment in infrastructure would be for the government to open up and encourage investment from the prospective users of the infrastructure through contracts on the basis of build-operate and-transfer (BOT). Presumably arrangements of this sort might attract considerable foreign investment if the government is able to back these schemes with instruments such as World Bank guarantees.

References

Ahmed, S. *Explaining Pakistan's High Growth Performance over the Past Two Decades: Can It Be Sustained?*". Washington: The World Bank, 1994.

Banerjee, A. , and et. al. "Exploring Equilibrium Relationships in Econometrics Through State Models: Some Monte Carlo Evidence." *Oxford Bulletin of Economics and Statistics* 42 (1986): 253-78.

Blejer, M.I. &, and M.S. Khan. "Public Investment and Crowding Out in the Caribbean Basin Countries." In *The Economics of the Caribbean Basin Countries*, edited by M. & Connolly and J. McDermott, 219-236. New York: Praeger, 1985.

Cuthbertson, K. &, S.G. & Hall, and M.P. Taylor. Applied Econometric Techniques. Ann Arbor: The University of Michigan Press, 1992.

Dickey, D.A. &, and W.A. Fuller. "Likelihood Ratio Statistics for Autoregressive Time Series With a Unit Root." *Econometrica* 49 (1981): 1057-72.

Engle, R.F. &, and C.W.J. Granger. "Co-integration and Error Correction: Representation, Estimation and Testing." *Econometrica* 55 (1987): 251-76.

Faiz, A. "Financing Infrastructure Investment." In *Financing Pakistan's Development in the 1990s*, edited by N Nasim, 191-224. Karachi: Oxford University Press, 1992.

Government of Pakistan. *Economic Survey 1994-95*. Islamabad: Finance Division, Economic Advisor's Wing, 1995.

Granger, C.W.J. "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods." *Econometrica* 37 (1969): 424-438.

Granger, C.W.J. "Some Recent Developments in a Concept of Causality." *Journal of Econometrics* 39 (1988): 199-211.

Granger, C.W.L. "Testing for Causality." *Journal of Economic Dynamics and Control* 2 (1980): 329-52.

Hall, R.E. *EViews User's Guide*. Irvine, California: Quantitative Micro Software, 1995.

Hamilton, J.D. *Time Series Analysis*. Princeton: Princeton University Press, 1994.

Haque, I. "Ninth Five-Year Plan Envisages 8% GDP Growth." *Dawn*, no. August 17 (1996).

Hendry, D.F. &, and G.E. Mizon. *Evaluating Dynamic Econometric Models by Encompassing the VAR*. Oxford: University of Oxford, 1990.

Hsiao, C. "Autoregressive Modeling and Money-Income Causality Detection." *Journal of Monetary Economics* (1981): 85-106.

Hsiao, C. "Causality Tests in Econometrics." *Journal of Economic Dynamics and Control* 7 (1979): 326-35.

IBRD. *Pakistan: Country Memorandum FY93, Progress Under the Adjustment Program*. Washington: The World Bank, 1993.

IBRD. *Pakistan: Current Economic Situation and Prospects*. Washington: The World Bank, 1992.

IBRD. *Pakistan: Current Economic Situation and Prospects*. Washington: The World Bank, 1991.

IBRD. *Pakistan: Review of the Sixth Five-Year Plan*. Washington: The World Bank, 1983.

IBRD. *World Development Report 1995*. New York: Oxford University Press, 1995.

Johansen, S. “Statistical Analysis of Cointegrating Vectors.” *Journal of Economic Dynamics and Control* 12 (1988): 231-54.

Johansen, S. &, and K. Juselius. “Maximum Likelihood Estimation and Inference on Cointegration--With Applications to the Demand for Money.” *Oxford Bulletin of Economics and Statistics* 52 (1990): 169-200.

Judge, G.G. &, H. & Griffiths, H. & Lutkephol, and T.C. Lee. *Introduction to the Theory and Practice of Econometrics*. New York: John Wiley and Sons, 1982.

Looney, R.E. “Manufacturing's Contribution to Pakistan's Economic Expansion.” Development Policy Review 12, no. 4 (1994): 369-386.

Looney, R.E. “Pakistani Defense Expenditures and the Macroeconomy: Alternative Strategies to the Year 2000.” Contsemporary South Asia 4, no. 3 (1995): 331-356.

Looney, R.E. “Public Sector Deficits and Private Investment: A Test of the Crowding-out Hypothesis in Pakistan's Manufacturing Industry.” The Pakistan Development Review 34, no. 3 (1995a): 277-299.

MacKinnon, J.J. “Critical Values for Cointegration Tests.” In Long-run Economic Relationships: Readings in Cointegration, edited by R.F. & Engle and C.W. Granger. Oxford: Oxford University Press, 1991.

Pesaran, H.M. &, and B. Pesaran. Microfit 3.0: An Interactive Econometric Package. Oxford, England: Oxford University Press, 1991.

Phillips, P.C.B. &, and S. Ouliaris. “Asymptotic Properties of Residual Based Tests for Cointegration.” Econometrica 58 (1990): 165-93.

Shiekh, A. “Ninth Plan Proposes Major Shift.” Dawn, no. September 3 (1996).
Stock, J.H. “Asymptotic Properties of Least Squares Estimations of Cointegrating

Vectors.” Econometrica 55 (1987): 1035-56.

Thornton, D.L. &, and D.S. Batten. "Lag-Length Selection and Tests of Granger Causality Between Money and Income." Journal of Money, Credit and Banking (1985): 164-178.

Notes:

[1] A full set of results is available from the author upon request.

[2] I am indebted to Yasmeen Mohiuddin for bringing this point to my attention.